AIRS QUARTERLY NEWSLETTER

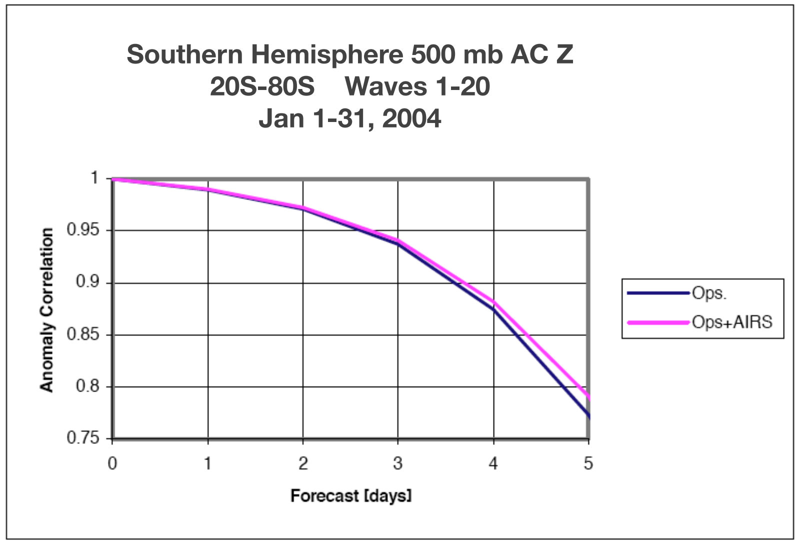
Research highlights and news from the AIRS Project Office at the Jet Propulsion Laboratory

SPRING 2005

ATMOSPHERIC INFRARED SOUNDER

AIRS IMPROVES FORECASTS

The Joint Center for Satellite Data Assimilation (JCSDA), established by NASA, NOAA, the U.S. Navy, and the U.S. Air Force to accelerate the assimilation of satellite observations into operational weather forecast models, has just announced that significant improvement in forecast skill has been achieved with the assimilation of AIRS data.



When compared to the rate of forecast improvement over the last ten years, the improvements made in global forecast capability in a relatively short time are quite significant—a several hour increase in forecast range at five or six days normally takes several years to achieve.

In the study, headed by JCSDA Director John LeMarshall, two series of parallel tests were run consisting of 27 consecutive 10-day weather forecasts from January 2004. In the control series, only conventional sources were used to initialize the forecast. For the experimental series, conventional sources plus AIRS observations were used.

To understand how the tests were conducted, three definitions need to be made clear. The term analysis refers to the combination of both the forecast model and the real weather data that drives the model. Forecast refers to results generated by the model only, and assimilation is the process of generating the analysis.

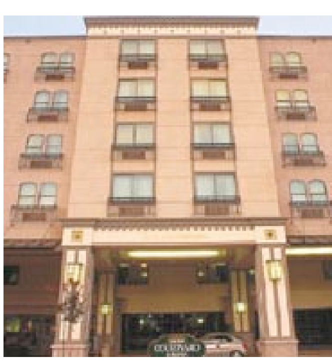
Picture a 27-day timeline that represents the analysis—the combination of forecast model and actual weather data. At each 6-hour interval along the length of the timeline a 10-day weather forecast is generated, initialized by the weather data at that point in time. Two timelines of analyses were run, one with AIRS data and one without.

When the results of the 10-day forecasts for both cases were compared to statistics from the National Weather Service, it became clear that the AIRS data had a significant effect on forecast skill over both hemispheres during this period. But because there is more conventional data coverage in the northern hemisphere than the southern, and because the use of AIRS data over land is currently limited, the forecast impact was slightly less in the northern hemisphere. The AIRS data was also used at less than full spatial and spectral resolution. Ongoing tests continue to be carried out with additional AIRS data.

John LeMarshall, Director of the Joint Center for Satellite Data Assimilation

The JCSDA has determined that if the accuracy gained in the experimental forecasts is mirrored when the AIRS data is used in operational weather forecasting, a significant gain in forecast skill will be realized.

More information can be found in EOS, Vol. 86, No. 11, March 15, 2005.



UPCOMING AIRS SCIENCE TEAM MEETING IN PASADENA CA

The next AIRS Science Team Meeting will be held in Pasadena, CA on May 3-6, 2005. All attendees must register online. Please refer to the AIRS web site for more information.

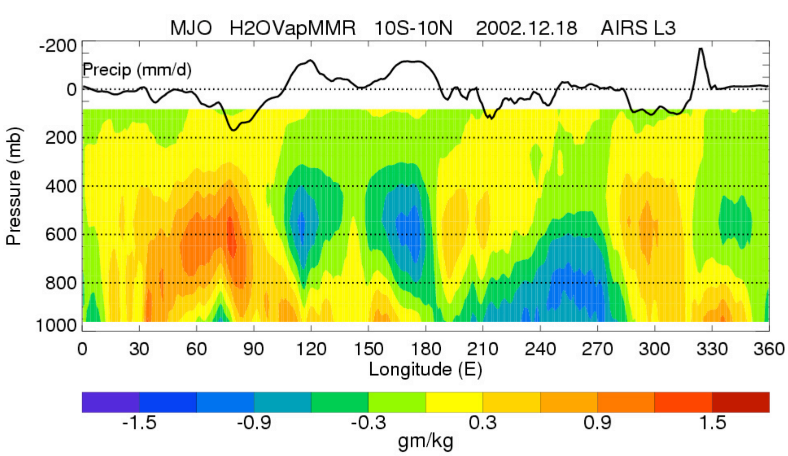
TO CATCH A WAVE

In 1971 while studying zonal winds in the tropical Pacific, Roland Madden and Paul Julian of the National Center for Atmospheric Research noticed what appeared to be the signature of a large-scale wave moving through the atmosphere. Now referred to as the Madden-Julian Oscillation, or simply MJO, this slow eastward-moving wave was found to stretch almost halfway around the world in a band that spanned the equator. In one phase of the wave, air slowly rises, triggering showers and thunderstorms, while in the other phase air slowly sinks, inhibiting clouds and rainfall. Changes between these phases occur approximately every 25-30 days.

The MJO wields its greatest influence in the Indian and western Pacific oceans where it affects the onset and break activity of the Asian-Australian monsoon system. But more than being a major factor in weather fluctuations in the tropics, the MJO can affect the winter jet stream and atmospheric circulation in the northern Pacific and western North America, causing anomalies that can lead to extreme rainfall events. In the summer, the oscillation can cause changes in rainfall patterns in parts of Mexico and South America. The MJO is even being looked at as playing a role in triggering variations in the El Niño Southern Oscillation.

Because of the wide range of weather phenomena associated with the MJO and the profound impacts these phenomena can have, it becomes essential that weather prediction supercomputers contain an accurate model of the wave. And a good model of the MJO will help forecasters better predict its effects, allowing people to better prepare for what's to come. But because of its complex nature, this has been no easy task.

Enter Duane Waliser and Baijun Tian. Duane, a Principal Scientist at the Jet Propulsion Laboratory and Baijun, a staff scientist at CalTech, are working together with members of JPL's AIRS science team to shoulder the task. The two have taken on the job of trying to properly represent the MJO in the general circulation models (GCMs) used for weather prediction and climate simulation. The most difficult challenge has come from trying to model the wave's hydrological components: water vapor and cloud, condensation, and evaporation processes. Most of the research on this problem has involved analysis of data in two dimensions—a horizontal plane in either the upper or lower troposphere. But Duane and Baijun are coming at the problem with something new—3-dimensional data from the Atmospheric Infrared Sounder.



This longitude-height cross-section plot shows the longitudinal and vertical structure of atmospheric water vapor anomaly associated with MJO rainfall anomaly.

The 3D structure of the high-resolution AIRS data may be the net that best traps the imprint of the MJO. Duane and Baijun are working to capture its signature in the AIRS data to create a depiction of the wave that can be compared to the model currently contained in the GCMs. The difference between the two should identify how the GCM should be corrected to properly represent the tricky MJO.

If Duane and Baijun meet with success, it could be hard to calculate what the improvement in forecast prediction could save in both money and lives. You could say there's a lot riding on the wave.

SUPPLEMENTAL

CDC Experimental MJO Projects
www.cdc.noaa.gov/MJO

NOAA Monitoring Intraseasonal Oscillations
www.cpc.noaa.gov/products/precip/CWlink/mjo_iso.html

Intraseasonal Variability of the Atmosphere-Ocean Climate System
Lau, W. K. M. and D. E. Waliser, Eds., 2005, Springer, Heidelberg, Germany, 474 pp.

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TRAVELING DOWN A BENT PIPELINE

In the business of forecasting the weather, there are two over-arching requirements levied on data fed into weather prediction supercomputers: they must be as accurate as possible and as immediate as possible. Mitch Goldberg, head of the Satellite Meteorology and Climatology Division at NOAA/NESDIS, knew that data coming from the AIRS instrument would be accurate enough to make the grade. But how could its extremely rich data, already stored on the spacecraft for up to 90 minutes after acquisition, get from satellite to ground, then processed and routed to numerical weather prediction centers around the world in less than the required 3-hour time limit?

Because of limitations in both communication bandwidth and computational resources at numerical weather prediction (NWP) centers, Mitch knew the first step had to involve thinning the AIRS data. But how?

To acquire data in both clear and cloudy conditions the AIRS infrared instrument works with a microwave instrument, AMSU-A, on the Aqua spacecraft. As both instruments scan Earth, each microwave field-of-view (FOV) footprint contains a 3x3 array of AIRS infrared FOV footprints. And each AIRS footprint contains 2378 data channels. Because of this large amount of AIRS data, simulations were run to see if a representative set of AIRS channels actually contained most of the atmospheric signal—and they did. Approximately 300 of the 2378 AIRS data channels were found to contain nearly all the signal of the full 2378-channel set. So the scheme to thin the data was set: Along with all 15 microwave data channels, a subset of AIRS data channels from the centermost footprint of the 3x3 grid are extracted for use by the NWP computers. The 9-fold reduction from using only the center footprint plus the roughly 8-fold reduction from using only 300 channels gave an almost 70-fold reduction in bandwidth.

Now that the data could be thinned enough, a new pathway to the computers at the NWP centers had to be created. The existing pipeline from spacecraft to ground had the data downlinked to receiving stations located in Norway and Alaska. These stations then routed the data via landline to a repository in White Sands, New Mexico, where it was funneled on to the EOS Data and Operations System (EDOS) at the Goddard Space Flight Center in Greenbelt, Maryland. At the EDOS the raw data was converted to instrument packet records and archived. The newly formatted data was then sent on to Goddard's Distributed Active Archive Center (DAAC) where it was further processed and finally archived. From end to end this pipeline took up to 3 days to traverse—a delay that was acceptable for the DAAC's climate-oriented customers. But clearly this would not work for the people in the business of weather forecasting.

And there was another problem. Spacecraft ephemeris tells exactly where the spacecraft is at any time—you need to know where the instrument is to know where it's looking. But the high precision ephemeris files take about 30 hours to calculate, so another solution needed to be found. Fortunately one was readily available. As part of the calculation of spacecraft ephemeris, predicted ephemeris files are generated that forecast the position of the spacecraft over the next few days. While the predicted files are not as accurate, it was found that the 100–meter difference was small enough to be acceptable. In the end, a little spatial accuracy would be given up for speed.

SUPPLEMENTAL

NOAA/NESDIS
www.orbit.nesdis.noaa.gov/star/index.html

AIRS Near-Real-Time Products and Algorithms in Support of Operational Numerical Weather Prediction
IEEE Transactions of Geoscience and Remote Sensing, Vol. 41, No. 2, February 2003

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Chris Barnet*
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** Chris Barnet has recently joined Mitch Goldberg's team. Chris was formerly with UMBC and is one of the lead AIRS Level 2 algorithm developers on the AIRS team.*

Satellite receiving station in Svalbard, Norway, 78 degrees north latitude.

It was time to implement the plan. With the help of NOAA's Walter Wolf, a new additional pathway—a "bent pipe"—for the data was devised. After the data stream reached the EDOS it would still get routed to the DAAC, but now it would also be simultaneously sent to a group of powerful Near–Real–Time (NRT) computers, owned by NOAA but located at the same NASA facility which houses the DAAC's computers. No more time would be spent making the data travel further. The NRT computers would prepare the data for use by the NWP centers by applying the thinning scheme and converting it to BUFR format, the type used by NWP computers. Several other thinning schemes are applied to create data sets for other purposes, but this single–FOV thinned–radiance data set became the type used by most weather forecasting centers assimilating AIRS data into their systems. Once the data was prepped, it could be distributed to the NWP centers.

In October of 2002 the effort to create a fast way to get AIRS data into the weather forecasting supercomputers became a reality—data flow through the bent pipe commenced.

Mitch Goldberg

- *The NASA Earth Observing System, EOS, of which the AIRS-bearing Aqua spacecraft is a major component, was designed to address research and climate applications. As such, the EDOS was not designed to deliver processed data until a day or two after the time of observation. However, shortly before the launch of Aqua it was decided that an effort should be made to make the AIRS data available to the weather forecasting community in time for them to use it. The effort to get the "bent pipe" both funded and implemented was an achievement that earned Mitch Goldberg the 2003 U.S. Department of Commerce Gold Medal.*
- *Today, NOAA/NESDIS distributes data to NWP centers domestically and internationally, including Europe, Japan, Naval Research Labs, and the UK Met Office, and forecasters around the world are now using AIRS data operationally for weather prediction. Soon, Mitch and his team will provide more enhanced products from AIRS including cloud cleared radiances, principal component reconstructed radiances, and geophysical products. This is just the beginning of a long relationship between NASA and NOAA working together to improve our quality of life on Earth and predict changes for the future.*

BEYOND THE SUN—ON THE HUNT FOR EARTH-LIKE WORLDS

Imagine being far out in space and looking back at Earth. Are there characteristics that could be deduced about our home planet even as a distant fuzzy ball? Thomas Hearty and Inseok Song think there might be. Thomas, a scientist at the Jet Propulsion Laboratory and Inseok, an astronomer at the Gemini Observatory in Hawaii, are using AIRS data to create spectra of the entire Earth as it would be seen by a distant observer. They believe that by examining the signature our own planet makes, we can come closer to understanding the signatures that other planets make. The two will be using what they find to help define requirements for the Terrestrial Planet Finder, a mission aimed at detecting Earth-like planets around other stars.

Previous whole-Earth spectra have been constructed indirectly using "Earthshine", i.e., reflected light from the dark side of the Moon. But this approach has only been able to produce spectra in the optical and near-infrared regions and is limited to edge-on viewing angles. Although some low-resolution spectra of the whole Earth have been obtained in the mid-infrared using the Thermal Emission Spectrometer onboard the Mars Global Surveyor, AIRS spectra are the first directly observed high-resolution infrared spectra that span all four seasons. Because AIRS also provides spatial information, its spectra can be weighted to simulate the spectra of extra-solar planets that could be similar to Earth. If Earth was a desert planet, what would its

SUPPLEMENTAL

Terrestrial Planet Finder
planetquest.jpl.nasa.gov/TPF/tpf_index.html

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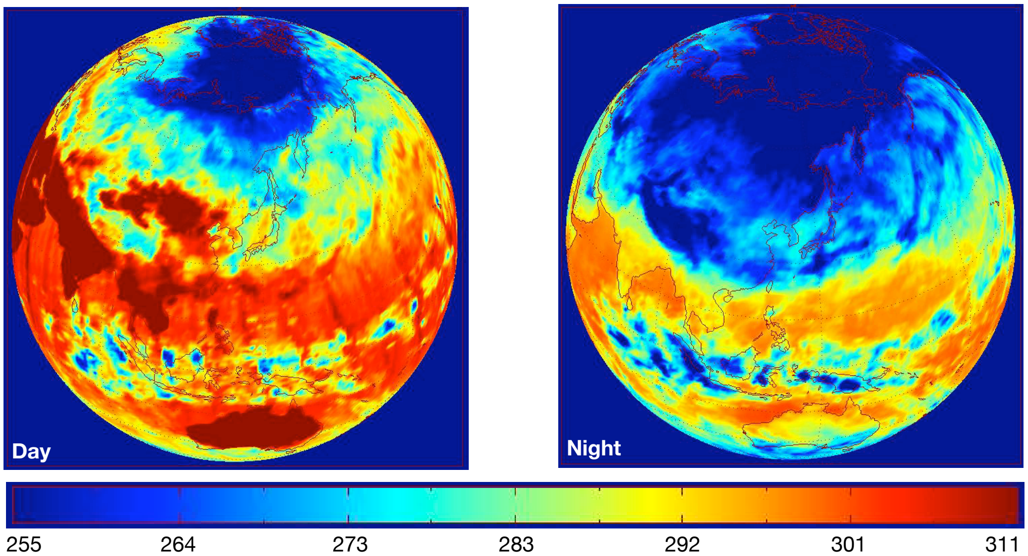
Thomas Hearty

spectral signature look like? If Earth was an ocean planet or snow-covered, what would we see? The data from AIRS may one day provide an important clue in interpreting the characteristics of planets beyond our solar system.



Day and night views of Earth at 4 microns.


Inseok Song

NEW PUBLICATIONS

Global Weather Prediction and High-End Computing at NASA
SJ. Lin, R. Atlas, KS. Yeh
Computing in Science and Engineering, IEEE, 1521-9615/04, January 2004

Synergistic Use of MODIS and AIRS in a Variational Retrieval of Cloud Parameters
J. Li, WP. Menzel, WJ. Zhang, FY. Sun, TJ. Schmit, JJ. Gurka, E. Weisz
Journal of Applied Meteorology 43 (11): 1619-1634, November 2004

Validating AIRS Upper Atmosphere Water Vapor Retrievals using Aircraft and Balloon In Situ Measurements
DE. Hagan, CR. Webster, Farmer CB, May RD, Herman RL, Weinstock EM, Christensen LE, Lait LR, Newman PA
Geophysical Research Letters, 31 (21): Art. No. L21103, November 6, 2004

Validation of Aqua Satellite Data in the Upper Troposphere and Lower Stratosphere with In Situ Aircraft Instruments
A. Gettelman, EM. Weinstock, EJ. Fetzer, FW. Irion, A. Eldering, EC. Richard, KH. Rosenlof, TL. Thompson, JV. Pittman, CR. Webster, RL. Herman
Geophysical Research Letters, 31 (22): Art. No. L22107, November 24, 2004

Hurricane Forecasting with the High-Resolution NASA Finite Volume General Circulation Model
R. Atlas, O. Reale, B. Shen, S. Lin, J. Chern, W. Putman, T. Lee, K. Yeh, M. Bosilovich, J. Radakovich
Geophysical Research Letters, Vol. 32, L03807, doi:10.1029/2004GL021513, 2005

Performance Expectations for Future Moderate Resolution Visible and Infrared Space Instruments Based On AIRS and MODIS In-Flight Experience
T. Pagano, S. Broberg, H. Aumann, R. Baron
Proceedings of SPIE, Vol. 5659, 97-104, 2005

The Precision and Accuracy of AIRS Level 1B Radiances for Climate Studies
T. Hearty, S. Gaiser, T. Pagano, H. Aumann
Proceedings of SPIE 5655-54, doi:10.1117/12.578991, 2005

The Atmospheric Infrared Sounder — An Overview
B. Lambrigtsen & al.
Proceedings of SPIE, Vol. 5652, 157-164 (2005)

Nighttime Cirrus Detection using Atmospheric Infrared Sounder Window Channels and Total Column Water Vapor
B.H. Kahn, K.N. Liou, S.-Y. Lee, E.F. Fishbein, S. DeSouza-Machado, A. Eldering, E.J .Fetzer, S.E. Hanson. L L. Strow
Journal Of Geophysical Research, 110, 10.1029/2004JD005430, 2005

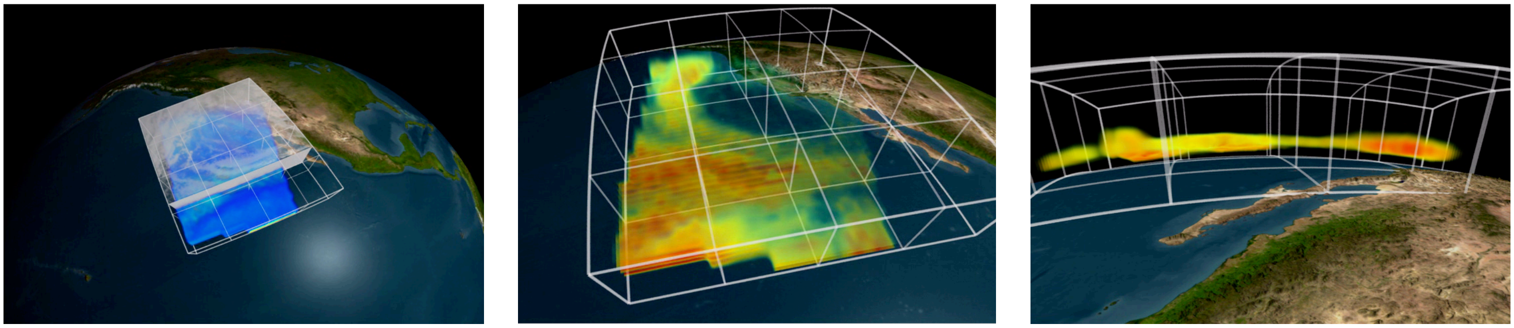
Quantifying Tropospheric Volcanic Emissions with AIRS: The 2002 Eruption of Mt. Etna (Italy)
S. A. Carn, L. L. Strow, S. de Souza-Machado, Y. Edmonds, and S. Hannon
Geophysical Research Letters, Vol. 32, L02301, doi:10.1029/2004GL021034, 2005

AIRS Hyperspectral Measurements for Climate Research: Carbon Dioxide and Nitrous Oxide Effects
H. Aumann, D. Gregorich, S. Gaiser
Geophysical Research Letters, 32 (5): Art. No. L05806, March 3, 2005

Impact of Atmospheric Infrared Sounder Observations on Weather Forecasts
J. LeMarshall, J. Jung, J. Derber, R. Treadon, S. Lord, M. Goldberg, W. Wolf, H. Liu, J. Joiner, J. Woollen, R. Todling, R. Gelaro
EOS, Transactions, American Geophysical Union, Vol. 86 No. 11, March 15, 2005

More publications can be found on the AIRS public website on the page labeled "For Researchers" at http://airs.jpl.nasa.gov/researchers/researchers.html.

NEW AIRS VISUALIZATION



A 3D LOOK AT ATMOSPHERIC WATER VAPOR
A new visualization from Goddard's Scientific Visualization Studio peels back clouds to show 3D AIRS data of a storm's water vapor content. The image then melts away to reveal the heart of the storm. You can view the visualization on the AIRS website.
Credit Greg Shirah

DATA NEWS

A new version of the AIRS data release means that the data has been processed to that version and the companion algorithms have been upgraded as well.

CURRENTLY IN OPERATION

Data Release version 4.0 is currently available at the Goddard DAAC, and data from April 1, 2005 to the present are being processed to 4.0. Reprocessing of earlier data has commenced. Eventually, all data from August 31, 2002 to the present will be processed to 4.0.

NEW IN VERSION 4.0

Data Release version 4.0 will be publicly available in April 2005. Here's what's new:
- Temperature is validated to 1K in 1 km vertical layers over ocean
- Water vapor is validated to 15% in 2 km vertical layers over ocean
- Improved retrievals over land
- Improved cloud properties
- Improved and expanded AIRS data quality indicators
- Radiance (Level 1B) are now half the size
- Gridded products (Level 3) are now available

New on the Goddard DAAC:
- Radiance data are now subsettable by date, geolocation, and channel
- Retrieved products (Level 2) are now subsettable by geophysical parameters
- Data from the Humidity Sounder for Brazil (HSB), a microwave sensor on board Aqua, ended in February 2003. The GDAAC has two sets of AIRS data from September 2002-February 2003. One set incorporates HSB data and the other does not.

HOW TO GET AIRS DATA

The Distributed Active Archive Center at Goddard Space Flight Center (GDAAC) serves as the central facility for the processing, archiving, and distribution of most EOS Aqua data.

DATA POOL—THE MOST RECENT AIRS DATA
daac.gsfc.nasa.gov/data/datapool/AIRS_DP/

WHOM—WEB HIERARCHICAL ORDERING MECHANISM
daac.gsfc.nasa.gov/data/dataset/AIRS

EOS DATA GATEWAY
redhook.gsfc.nasa.gov/~imswww/pub/imswelcome

RESOURCES AND HELP

AIRS DATA SUPPORT
http://disc.gsfc.nasa.gov/AIRS/

AIRS PUBLIC WEB SITE
airs.jpl.nasa.gov

ASK AIRS—ONLINE FORM FOR QUESTIONS ABOUT DATA AND PRODUCTS
airs-inquiry.jpl.nasa.gov/feedback/feedback_form.cfm/

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SUBMIT TO THE AIRS QUARTERLY

If you would like to submit a story idea, image, news, or other content, please send an email to Sharon Okonek at **sharon.okonek@jpl.nasa.gov**.

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